ATHENA Barrel Studies with Geant4

Ryan Milton
UCLA
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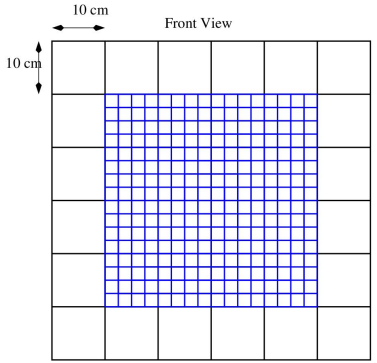
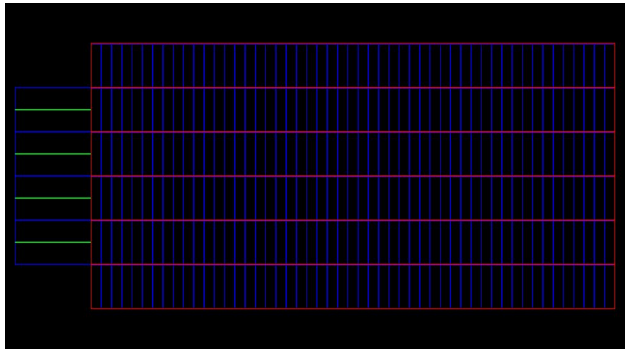
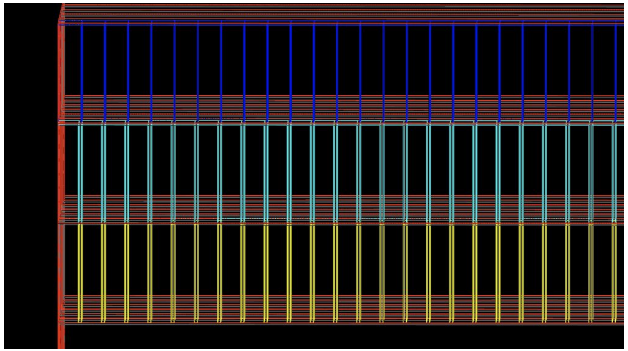
Model

- Using W/ScFi ECal with 8x8 block structure
  - Each block about 5 x 5 cm, with 3120 fibers in each
- HCal (red) made of 6x6 towers of about 10x10 cm
  - Towers divided into 51 **layers** (blue)
  - Each layer has 2cm of Fe absorber (cyan) and 0.3 cm of scintillating **tile** (yellow)
- First 11 layers (25.3 cm) of HCal are made non-sensitive to act as dead material
  - Serves as the magnet material in the barrel
  - From this point forward, first layer or layer 1 refers to the first **active layer** (i.e. layer 12 originally)

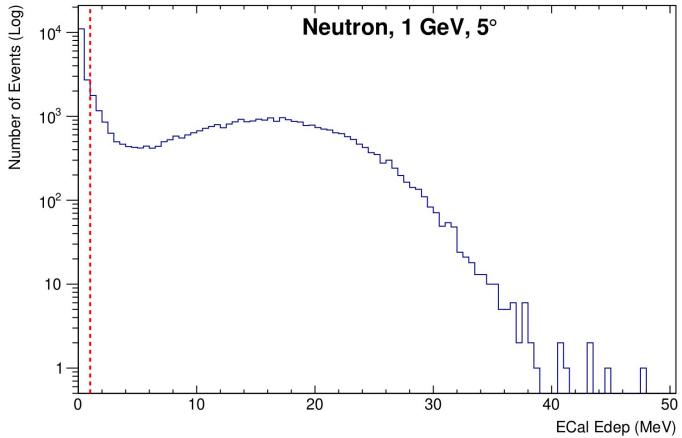






Simulation & ECal Cuts

- Using neutrons at 5° between 1 GeV and 10 GeV
- **Choose ECal cut of 1 MeV** to remove noise
- ECal sampling fraction is 2.8%, so 1 GeV particle will deposit 28 MeV (experiment)
- 28 MeV will generate 1000 photoelectrons or 1000 pixels fired in SiPMs (experiment)
  - So 35 pixels fired per 1 MeV
  - Typical noise for SiPM is 2-3 photoelectrons, so 35 pixels is well above noise levels
  - But, 1 MeV can be spread across many SiPMs, each with few counts and on level of noise
  - 1 MeV is a bit arbitrary but reasonable
  - Any event with < 1 MeV in ECal has 0 hits and 0 MeV

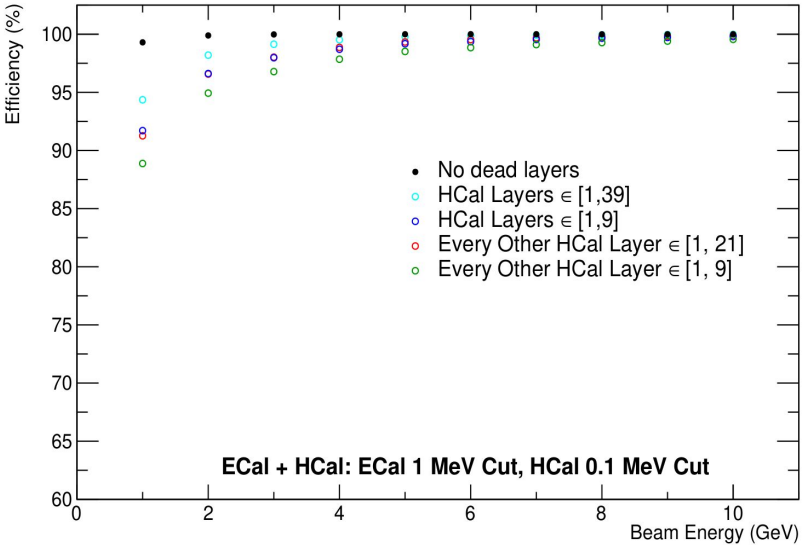


HCal Cuts & Efficiency

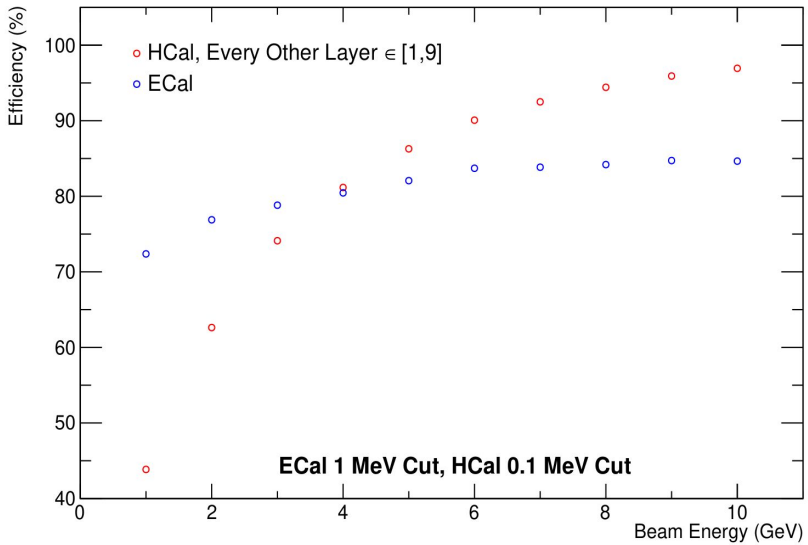
- Considering HCal energy deposition tile-by-tile
- If a tile has **< 0.1 MeV** deposited, that tile gets changed to 0 hits and 0 MeV deposited.
- Define **efficiency** as ratio of number of events with non-zero hits to total number of events
  - Efficiency = non-zero events/total events
  - For entire detector (ECal and HCal), event with zero hits has no hits in ECal **and** no hits in HCal
    - Particle gets stuck in dead layer and does not shower in ECal or HCal
  - Can also do this for just the ECal or HCal

Efficiency Plots

- Efficiency close to 100% with no dead layers, so there is unpreventable loss of efficiency at low energies due to magnet
- Efficiency does not improve significantly with more HCal layers
  - Helps justify using 5 layers for barrel
- Every other layer since the real barrel will have 4 cm absorber plates



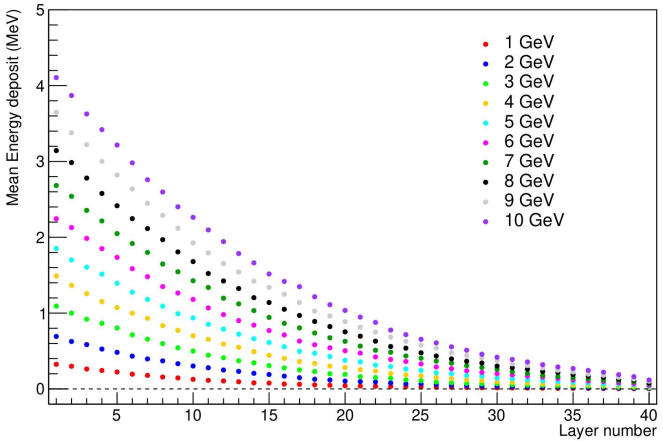
Combined ECal and HCal efficiency

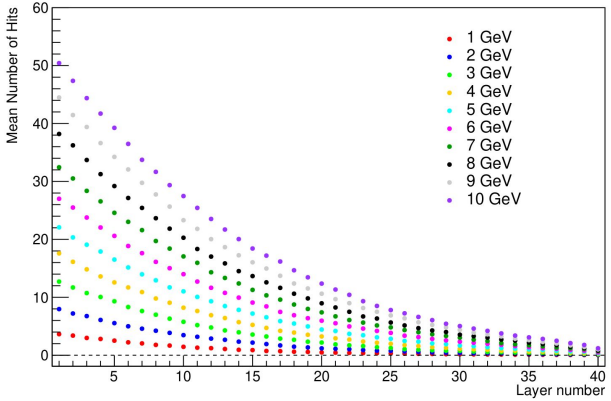


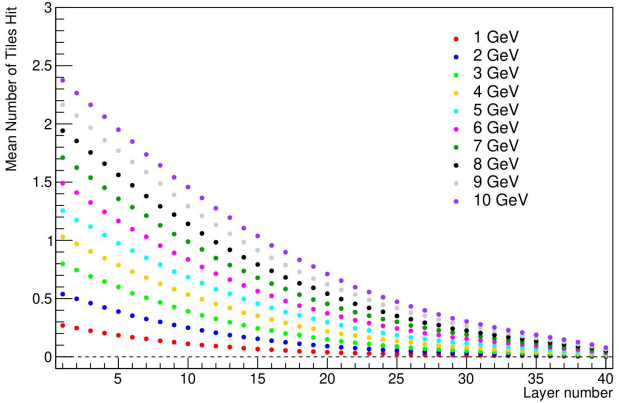
Separate ECal and HCal efficiency

HCal Layers

- Layer and tile information can be helpful for pattern recognition and future ML approaches
  - Can see how the showers spread out in the HCal layers







Tile Distribution

- Can look at sum of number of tiles hit in layers 1, 3, 5, 7, 9
- Consistent with the efficiency of the HCal
  - More tiles hit as energy increases
- Possibility for pattern recognition since there are multiple tiles hit at each energy